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Review Article

Applications for Vehicle Speed Detection: A Systematic Review from 2013 to 2024

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Abstract - *In the last decade, research on intelligent vision applied to vehicle speed detection has grown significantly due to the need to optimize traffic control and improve road safety. This study, supported by the objective of identifying mobile applications that implement intelligent vision for vehicle speed detection and based on the STAR methodology, identified 79 documents in databases such as Scopus and PubMed related to this topic. The results show that China leads the scientific production in this field, followed by the United States and India. At the same time, Latin American countries, such as Mexico and Chile, have a lower participation. In terms of thematic areas, most research comes from Computer Science (46.6%), Engineering (35.9%), and Mathematics (14.5%), reflecting the predominance of a technological approach. Furthermore, 57% of the documents correspond to conference papers, indicating a tendency to present advances at specialized events before consolidating them into scientific articles. In conclusion, intelligent vision applied to vehicle speed detection represents a key tool for traffic management and road safety, with growing interest in deep learning, image processing, and automatic detection algorithms. However, the limited participation of some countries and disciplines suggests the need to foster interdisciplinary research and global collaborations to maximize the impact of these technologies in different urban and regulatory contexts.*

Keywords - *Mobile applications, Intelligent vision, Vehicle speed detection, Traffic safety, Computer vision.*

1. Introduction

In recent years, there has been a considerable increase in the number of vehicles on the roads, which has led to a significant increase in traffic congestion and accidents [1]. Therefore, excessive speed has generated significant economic and social costs in various parts of the world since, despite efforts to improve road safety, traditional surveillance methods have proven ineffective in addressing these problems adequately [2]. In this context, the implementation of computer vision technology for vehicle speed detection has taken on significant international importance. Countries such as Australia and the United Kingdom have implemented advanced systems that have significantly reduced the incidence of violations and accidents.

These advances demonstrate that using automated tools improves road safety and reduces the administrative burden and the margin of error in traffic enforcement [2]. These solutions, which integrate image recognition, machine learning, and automation, represent a significant advance compared to traditional enforcement models. In Latin America, several countries have implemented smart vision-based solutions for vehicle speed control. A proven case is the development of a camera system with Optical Character Recognition (OCR) and computer vision to monitor traffic and effectively enforce electronic sanctions. However, corruption in enforcing these measures remains a challenge in the region. A recent study on corruption in traffic enforcement in Latin America highlights that a lack of transparency and the manipulation of sanctions are common problems that undermine public confidence in vehicle control systems [3].

In Peru, the growth of the vehicle fleet and the lack of effective control have led to increased traffic accidents. Traffic surveillance in Lima continues to depend largely on the manual intervention of traffic officers, a method that has proven ineffective due to corruption and human error [3]. According to Canal N, since 2024, 194 accidents have been recorded in Metropolitan Lima, causing the deaths of nearly 200 individuals, with speed being one of the most prominent causes [4]. This situation highlights the need to modernize enforcement mechanisms through more technological, efficient, and reasonable solutions. In this context, mobile applications with intelligent vision emerge as a promising alternative to improve traffic monitoring, reduce corruption, and strengthen road safety. However, the current literature is notably uneven. Although there are multiple studies on the use of computer vision in fixed contexts (urban cameras or infrastructure-mounted systems), few studies have organized the evidence on mobile applications specifically designed for vehicle speed detection and their influence on traffic management. Furthermore, most studies focus on technical elements, ignoring equally important aspects such as implementation feasibility, ease of use in mobile contexts, or social and legal acceptance. This lack of comprehensive review makes it difficult to compare approaches and limits the generation of new contextualized proposals.

Therefore, this article aims to systematically review mobile applications that implement intelligent vision for vehicle speed detection from 2013 to 2024. It will analyze the technologies used and their effectiveness, ease of use, and accuracy in identifying violations. It will also assess the impact of these solutions on reducing corruption and optimizing traffic monitoring to promote more equitable and efficient management in urban environments.

Systematic reviews are fundamental in generating a knowledge- and evidence-based framework. They allow for the analysis of the evolution and impact of a field of study over time, identifying trends, practical methodologies, and research gaps. In the case of intelligent vision for vehicle detection, these reviews facilitate the comparison of different technological approaches and their implementation in various regions. Furthermore, tools such as VOSviewer allow for the visualization of co-authorship networks and relevant keywords, which helps identify development patterns and areas of opportunity for future research [5].

This article is structured into five chapters. Chapter I presents the background of the problem, the justification, and the study's objectives. Chapter II provides a comprehensive literature review on smart vision technologies applied to vehicle speed control, analyzing their effectiveness and limitations. Chapter III describes the methodology used, based on the Scopus and PubMed databases and complemented by the STAR model to ensure rigor in the systematic review.

Additionally, the VOSviewer tool was used to analyze research trends and evaluate co-authorship networks. Chapter IV presents the results obtained, including graphs and maps that reflect the main advances in the development of smart vision mobile applications. Finally, Chapter V presents the discussions and conclusions, comparing the results with previous studies and proposing strategies for improving these technologies in road safety.

2. Literature Review

Urban traffic management faces numerous challenges, primarily due to the increasing number of vehicles and the limitations of current systems. However, with the development of computer vision and data analysis techniques, promising solutions are emerging that can improve traffic control. This section reviews recent research that applies segmentation and optical flow to identify vehicles and estimate congestion. In the field of computer vision applied to vehicle detection, the study [6] reflects the use of YOLOv8 technology for the automatic detection of cars on roads, surpassing its predecessor YOLOv5 in terms of average precision (mAP) with 98.8%, in addition to improving the training speed by 50%, making it ideal for real-time applications. In complementary research, [7] proposed a method to detect shadows projected by vehicles to improve driving assistance systems and reduce the risk of frontal collisions. This approach showed up to 97.94% rates on cloudy days, highlighting its robustness against environmental variations.

Regarding urban impacts, [8] addressed the effects of vehicular growth on mobility and the environment, indicating a 30% increase in congestion and a 25% increase in CO_2 emissions. Through a review of computer vision techniques, the study showed that methods such as YOLO-CA have achieved 90.02% in accident detection, while Faster RCNN has achieved 92% in emergency vehicle identification. Despite these advances, a standard limitation is the lack of standardization of data sets, which greatly hinders the comparison between models and their replicability in other contexts.

The study by [9] points out that traffic congestion affects both the economy and environmental sustainability, highlighting computer vision as a key solution through deep learning and object segmentation techniques, achieving up to 96.55% accuracy in vehicle detection. Likewise, [10] analyzes the inefficiency of traditional traffic control systems and reviews computer vision-based methods for autonomous vehicle flow management, achieving significant improvements in traffic signs and accident detection.

However, the study highlights that the lack of standardization and homogeneous datasets limits the real-world application of these technologies. On the other hand, [11] presents a proposal for tracking moving objects with wireless pan-tilt cameras, optimizing detection accuracy and reducing energy consumption by 38%. This technology allows for longer tracking, up to eight times the duration of traditional methods and demonstrates its applicability in energy-restricted environments. Despite these advances, the implementation of intelligent traffic monitoring and control systems faces challenges such as environmental variability and the need for more representative data to improve their performance in real-world scenarios.

In terms of road safety, [12] presents a hybrid system that combines YOLOv4, Part Affinity Fields (PAF), and Convolutional Neural Networks (CNN) for pedestrian detection and analysis. Their approach achieves a 74% reduction in YOLOv4 parameters and a 2.6% improvement in detection accuracy, reaching 96.55% in object identification.

However, the lack of standardized data remains an obstacle to its implementation. On the other hand, [13] addresses urban traffic management using CNNs to estimate vehicle queue lengths from low-resolution videos without requiring prior camera calibration. Comparing different models, the study selects YOLOv4, achieving an accuracy of 93%. However, it highlights the lack of standardized data and the challenges faced with adverse conditions such as occlusion and low resolution.

Regarding vehicle identification, [14] develops a system that combines YOLOv8 and OCR to detect and recognize vehicle license plates. Starting from 270 annotated images, the method applies processing techniques such as k- k-means. Clustering and thresholding, achieving an accuracy of 99% in detection and 98% in character recognition, outperforming previous approaches. Finally, [15] addresses the challenge of distortion in railway inspections using a real-time speed measurement technique, which adjusts the camera frequency according to the variation in train speed.

After testing on Line 17 of the Shanghai Metro, it was shown that the system measures speeds with an error margin of only 1.2 km/h, guaranteeing clear images in different operating conditions. Despite these advances, most research focuses on highly structured contexts (such as highways or train lines) with advanced infrastructure. In this regard, there is a significant gap regarding the use of smart vision mobile applications for vehicle speed detection in less structured urban contexts, where technological resources are scarce and where corruption rates in inspections remain high, as is the case in many regions of Latin America.

This systematic review is unique in focusing solely on mobile applications integrating intelligent vision for vehicle speed detection. Unlike previous studies that evaluate individual components (detection and segmentation models), this study takes a holistic approach that evaluates various characteristics of such studies.

3. Methodology

This study uses the STAR methodology, which includes four phases: Situation, Task, Action, and Results. This structured approach is widely used in data collection and analysis in interviews and performance evaluations. Its format allows complex situations to be broken down into understandable elements, facilitating the analysis of decisions and their consequences. Its application has proven beneficial in various areas, such as mental health decision-making, where it allows for a practical assessment of sociotechnical resources [16].

3.1. Phases of the STAR Methodology

3.1.1. Situation

In this first phase, the context of the study is established, offering a precise perspective of the problem [17]. In this case, the analysis focuses on mobile applications for speeding detection and their impact on traffic surveillance. To this end, a comprehensive analysis was performed on databases such as Scopus and PubMed to obtain relevant information on technological developments applied to traffic control [27].

3.1.2. Task

In this phase, selection and inclusion criteria filter the obtained studies [18], considering only those that address the effectiveness, accuracy and ease of use of smart vision-based mobile applications for vehicle speed detection. This process ensures the concordance of the studies with the research objectives, ensuring the quality and relevance of the analyzed data [28, 29].

3.1.3. Action

In the third phase, a detailed evaluation of the selected studies [19] is carried out, considering key aspects such as the accuracy of the vision algorithms, their ease of use for users, and their impact on the transparency of traffic control. Studies that did not meet these criteria were excluded, ensuring the analysis was based on relevant and reliable information [30].

3.1.4. Results

In this last phase, the quantifiable or qualitative results arising from the study are presented [20]. In addition, the findings are synthesized, providing a complete perspective on the effectiveness of these applications in identifying speeding violations and their ability to improve traffic management. Based on these results, suggestions are made to improve the implementation of these technologies in urban environments [31].

3.2. Applicability of the STAR Methodology

The STAR methodology has proven to be effective in the evaluation of traffic control technologies, facilitating the identification of advances and improving decision-making in intelligent vision applications [21, 32]. Its use extends to business strategic planning, allowing it to improve performance and encourage continuous improvement [22, 25, 26, 33].

Furthermore, its approach based on quantifiable results [23] makes it a valuable tool in Engineering and Technology [34]. This methodology provides a competitive advantage in dynamic work environments, enabling effective problem-solving through a systematic approach [24].

Furthermore, its accessibility makes it ideal for reviewing intelligent vision applications in traffic, promoting data-driven decisions that contribute to more efficient surveillance and fair sanctions [32, 34]. This highlights the usefulness of the methodology in vehicle speed detection [35] and its implementation by international organizations interested in optimizing processes and obtaining better long-term results [36].

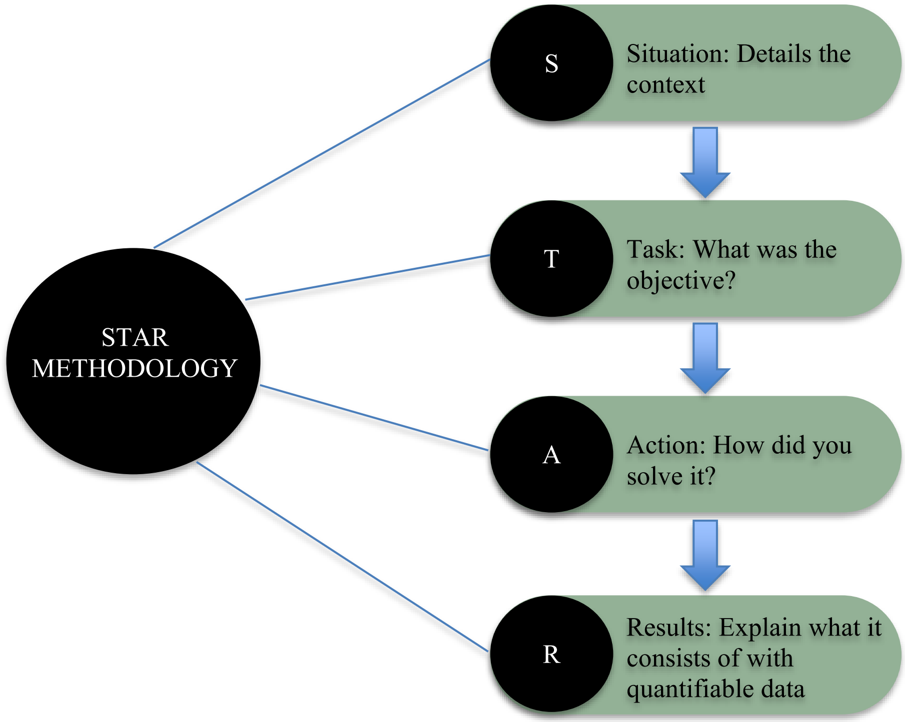

Fig. 1 Star methodology flowchart

3.3. Tools to Implement the STAR Methodology

3.3.1. Scopus

Scopus is an essential database for academic research, providing access to a vast collection of peer-reviewed studies. This review used it to gather information on smart vision applications and analyze the quality of the information-the scientific literature on traffic control [37]. In addition, Scopus allows advanced searches and access to metrics to evaluate the impact of research and trend tracking and citation analysis to obtain a global view of the state of knowledge [38].

3.3.2. VOSviewer

Vosviewer is a software specialized in the visualization of scientific networks, allowing researchers to create co-citation maps, co-authorships and co-occurrences of terms. This is especially useful for discovering patterns in studies related to intelligent vision technologies in traffic [39]. Furthermore, it facilitates the analysis of large volumes of bibliographic data, helping to identify emerging trends in traffic surveillance [40]. This tool is key to placing research within the broader context of scientific development in this area [41].

3.3.3. Python

Python is key to analyzing big data and developing algorithms for vehicle speed detection using smart vision. In this review, libraries such as OpenCV were used to process images and NumPy to handle numerical data, achieving improved accuracy in traffic control [42]. Additionally, YOLO was used for real-time detection of vehicles exceeding speed limits, improving identification in complex environments [43]. With its versatility, Python is preferred for machine learning models in vehicle control automation [44].

4. Results

The primary objective of data collection was to analyze mobile applications that implement intelligent vision for vehicle speed detection.

4.1. Analysis of the Situation Phase

In this step, a Boolean search algorithm was designed and applied to academic databases such as Scopus and PubMed. The AND and OR operators were used to combine terms, facilitating the search for documents relevant to the study. The algorithm also includes a time constraint, selecting documents available between 2013 and 2024, ensuring that the research analyzed is in a current context.

The selection criteria for the documents were based on the following algorithm: (TITLE-ABS-KEY (intelligent AND vision) AND TITLE-ABS-KEY (vehicle AND speed AND detection) AND TITLE-ABS-KEY (mobile AND applications) OR TITLE-ABS-KEY (application)) AND PUBYEAR > 2012 AND PUBYEAR < 2025

This method facilitates the precise identification of studies, as it ensures rapid and efficient data searches, improving the results obtained. In the initial search, the total number of documents found was 180.

4.2. Analysis of the Task Phase

Regarding selecting and including sources, a specific criterion was developed to consider only journal articles, high-value indexed conference papers, and systematic reviews. This approach ensures the quality and relevance of the selected documents, excluding irrelevant or outdated sources of information. This filter is detailed in Table 1.

Table 1. Filters by document type

Inclusion of Sources by Document Type	
Document Type	**Number of documents**
Conference paper	80
Article	50
Review	7

4.3. Analysis of the Action Phase

With the documents selected according to the previous filter, a subject area exclusion was performed to exclude documents from subject areas unrelated to the topic of smart vision mobile applications. This filter is shown in Table 2.

Table 2. Filters by subject area

Exclusion of Sources by Subject Area	
Areas excluded	**Number of documents**
Agriculture and Biological Sciences	5
Biochemistry, Genetics and Molecular Biology	2
Chemistry	2
Energy	10
Physics and Astronomy	18
Decision Sciences	16
Medicine	8
Environmental Science	4
Neuroscience	1
Earth and Planetary Sciences	2
Materials Science	7
Business, Management and Accounting	3

Finally, a general exclusion of the selected articles was performed, thoroughly examining the 180 documents obtained in the initial search. Through inclusion and exclusion screening, the total number of documents was reduced to 79, which will be used for the subsequent stages of the analysis.

4.4. Analysis of the Results Phase

This section presents the key findings of the systematic review of smart vision mobile applications for vehicle speed detection. This study aims to identify current trends and the most notable applications in this area, evaluating their effectiveness and applicability in various monitoring and road safety contexts. The STAR methodology was used to structure data collection and analysis, allowing for a clear and systematic information organization in each phase. The results are detailed below and grouped into categories relevant to the study.

Figure 2 shows the evolution of research by year in intelligent vision applied to vehicle speed detection between 2013 and 2024. In the early years, scientific production was limited, with only two studies in 2013 and six in 2014 and 2015. However, from 2017 onwards, with three studies registered, interest in this area began to increase steadily. Between 2018 and 2022, the number of research studies varied between five and nine studies per year, reflecting progressive growth. In 2023, a notable increase was observed with eight studies, reaching its peak in 2024 with 14 publications. This sustained increase highlights the growing relevance of intelligent vision in road safety and traffic management. Figure 3 shows the distribution of applied smart vision research by subject area. Computer Science (61 studies) and Engineering (47 studies) stand out as the main contributors to the development of this technology, reflecting its relevance in the design of algorithms and advanced systems. Mathematics also plays an important role in 19 studies, primarily in the development of analytical models and methods. In contrast, the contribution of the Social Sciences is significantly smaller, with only four studies indicating a technical focus in this area.

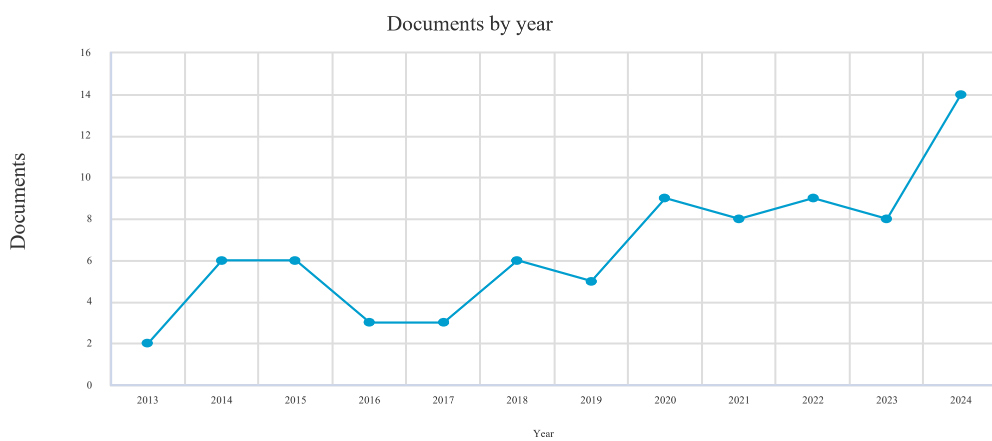

Fig. 2 Analysis by year

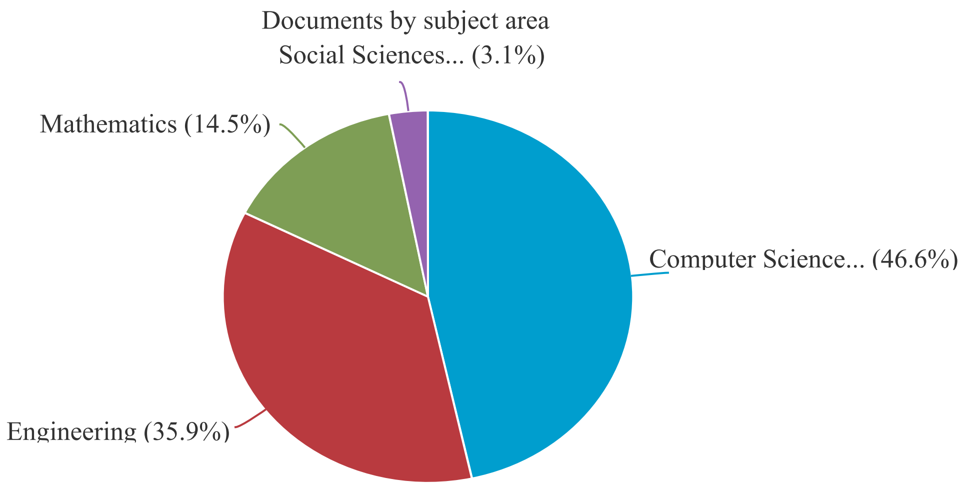

Fig. 3 Analysis by thematic area

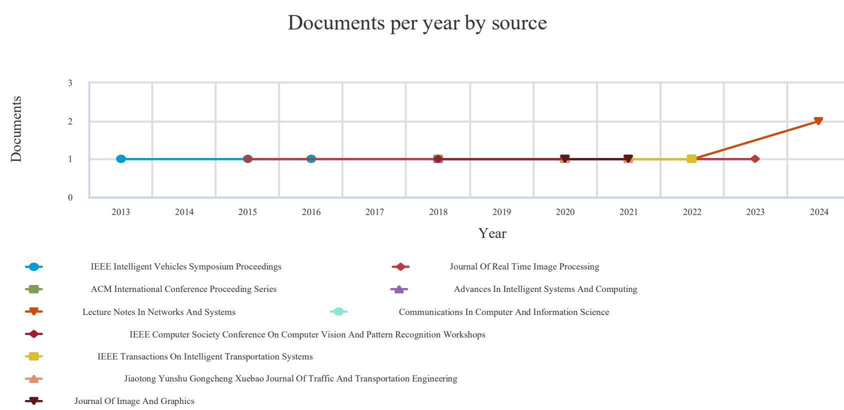

Fig. 4 Analysis by journal

Figure 4 presents the number of papers published in various academic sources between 2013 and 2024 on mobile applications of intelligent vision for vehicle speed detection. IEEE Intelligent Vehicles Symposium Proceedings, Journal of Real-Time Image Processing and Lecture Notes in Networks and Systems, each with three publications, reflecting their relevance in the technological field. Other sources, such as the ACM International Conference Proceeding Series and Advances in Intelligent Systems and Computing, with two publications each, have also contributed to the development of the field. The diversity of journals suggests the need to consider journals and conferences with ongoing impact on Artificial Intelligence (AI) and computer vision for future research.

Figure 5 shows the distribution of scientific papers on intelligent vision applied to vehicle speed detection according to their publication type. The majority are conference articles, accounting for 57% of the publications, indicating a tendency toward presenting advances at academic events. Journal articles represent 38%, reflecting more established and peer-reviewed studies, while systematic reviews constitute 5.1%, suggesting a smaller number of studies focused on global analysis of the state of the art. This distribution highlights the dynamic nature of the field, where innovation advances rapidly through conferences before being consolidated in specialized journals.

Figure 6 shows the geographic distribution of research on intelligent vision applied to traffic violation detection between 2012 and 2024. China leads the way with 31 studies, reflecting its strong investment in advanced traffic monitoring technologies. The United States, with eight, and India, with seven, also represent significant participation, highlighting their contributions to the development of AI for road safety. To a lesser extent, Latin American countries such as Chile, Ecuador, and Mexico represent a minimal fraction of the research. These data demonstrate a concentration of studies in countries with high technological development and policies focused on traffic optimization through intelligent vision.

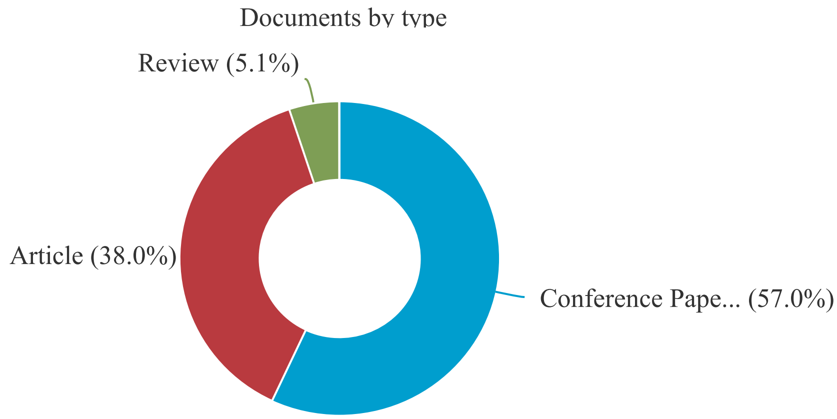

Fig. 5 Analysis by document type

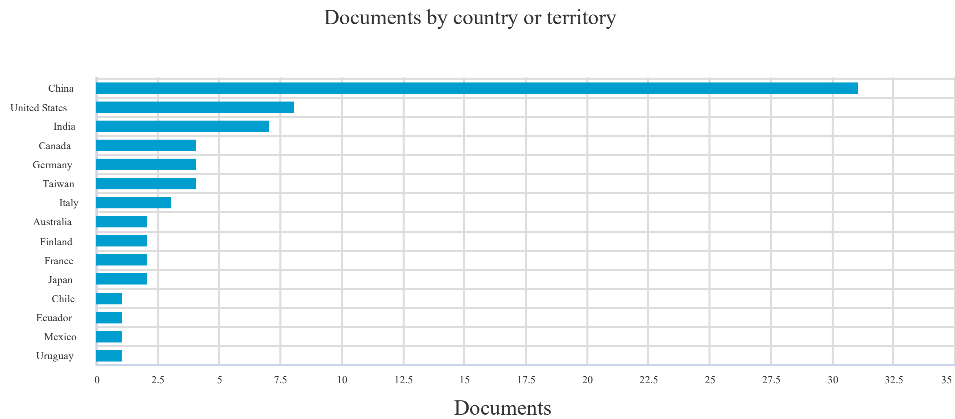

Fig. 6 Analysis by country

Figure 7 shows the scientific production in intelligent vision applied to vehicle speed detection. Nedevschi, S., with two publications, stands out as the author with the highest number of documents, consolidating his influence in the development of technologies in this area. On the other hand, Ahmad, N., Ai, W., Akbar, M.A., and Akoushideh, A. made individual contributions with one publication each. These data reflect a dispersed distribution of authorship, suggesting that the field is still growing and is not dominated by a small group of researchers.

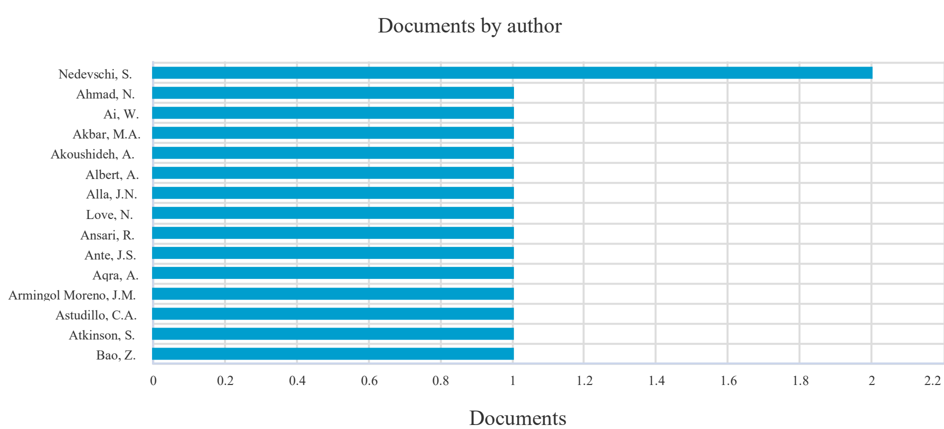

Fig. 7 Analysis by author

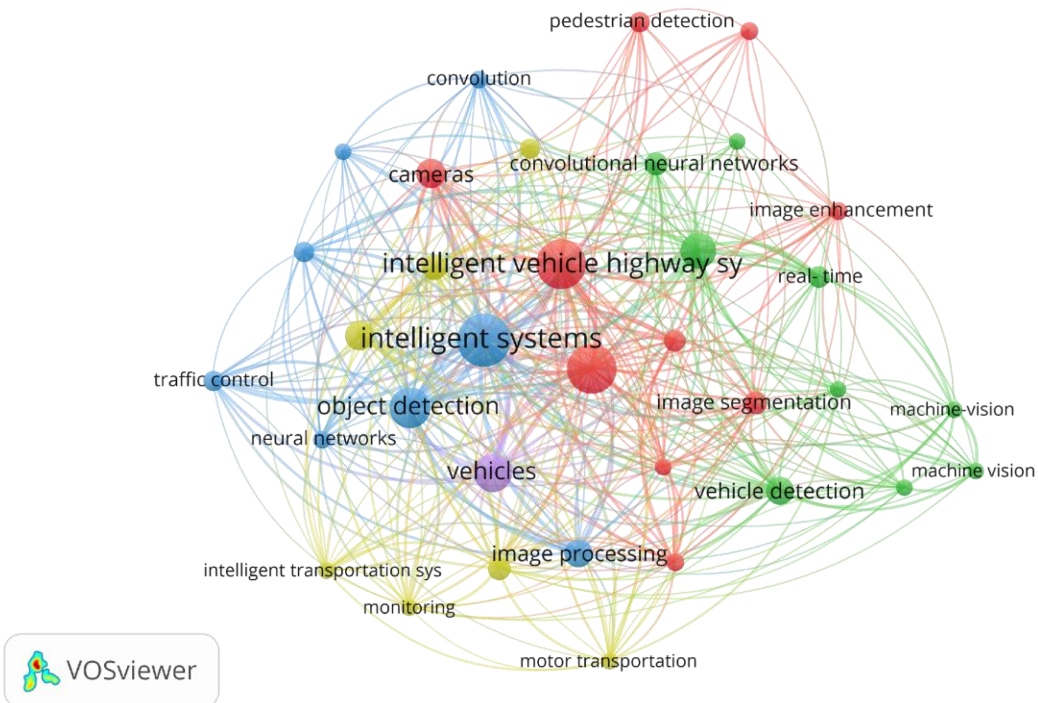

Fig. 8 Co-occurrence of keywords

Figure 8 shows the keyword co-occurrence for 861 indexed keywords in the reviewed publications. It can be seen that the word 'intelligent' systems' has 32 occurrences, followed by 'intelligent' vehicle highway sy' and 'computer vision' with 29 appearances.

In this sense, 35 occurrences were identified, distributed in five clusters: cluster 1 (10 occurrences), cluster 2 (9 occurrences), cluster 3 (8 occurrences), cluster 4 (7 occurrences), and cluster 5 (1 occurrence). Each set of keywords was illustrated with different colors through the VOSviewer visualization tool, facilitating the identification of thematic patterns. In this analysis, cluster 1 (red) stands out for having "intelligent vehicle highway sy" as the main node, grouping keywords like "computer" vision" and "cameras". Cluster 2 (green) stands out with its main node of "deep learning", grouping keywords such as "vehicle detection" and "convolutional neural networks". These results allow us to differentiate the main themes of each cluster and understand the dynamics of research on mobile applications of Intelligent Vision for Vehicle Speed Detection.

5. Discussion and Conclusion

The findings of this study reflect the sustained growth in research on intelligent vision applied to vehicle speed detection. The year-by-year analysis shows a significant increase in studies since 2017, peaking in 2024, indicating a growing interest in optimizing traffic control through advanced technologies.

The analysis by thematic area reveals that the disciplines with the most excellent scientific output in this field are Computer Science, Engineering, and Mathematics, which demonstrates the technological focus of this research. However, the impact of the Social Sciences is limited, with only four studies represented, suggesting less exploration of factors such as public perception and regulation in the implementation of these technologies. Regarding output by country, China leads with 31 studies, surpassing the United States, India, Canada, and Germany. This dominance reinforces China's role in the development of advanced technologies for detecting traffic violations. This figure contrasts with the limited scientific output in Latin America, highlighting the importance of promoting research programs applied to regional contexts, particularly in countries with high traffic accident rates and poor effective supervision.

In contrast to previous studies, this study confirms the importance of computer vision in optimizing vehicle control [7, 9]. Previous research has highlighted the use of deep learning algorithms to improve speed detection and offender identification accuracy [5, 6]. However, this study achieved better results regarding thematic area, social variables, and geographic contextualization, allowing for a more complete view of the state of the art. This study highlights the importance of emerging technologies in improving road safety. The implementation of intelligent vision systems not only optimizes violation detection but can also contribute to fairer and more efficient traffic management. However, the low representation of some countries and disciplines suggests that research is expanding, particularly in countries with high road accident rates. Another significant advance compared to previous research is the clear delineation of the focus on mobile applications with intelligent vision for vehicle speed detection, an emerging field with high applicability in dispersed urban environments where fixed cameras or conventional systems are not feasible. While previous studies focused on high-end or static platforms, this analysis highlights mobile and lightweight technologies that could be used in developing countries. For future studies, it is recommended to expand the analysis to include the social and legal impact of these technologies and to explore their integration with other smart solutions, such as autonomous transportation systems and real-time monitoring via IoT. This would foster international collaborations and diversify scientific production to different urban and regulatory contexts.

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